

LB/DON/46/04

No 12



UNIVERSITY OF MORATUWA
SRI LANKA

**DESIGN MODELING AND SIMULATION OF A
REPEATERLESS OPTICAL FIBER NETWORK FOR
SRI LANKA**



**Submitted in partial fulfillment for the degree of Masters of
Engineering in Electronics and Telecommunication**

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February 2004

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The work presented in this dissertation has not been submitted for the fulfillment of any other degree



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DEDICATION

I dedicate this Dissertation with a lot of respect to my lovely late Mother who directed me to achieve the best possible education through a lot of dedication and hard work.

It is also with reverence and respect that I remember my Father, my school - Thurstan College and University of Moratuwa for the guidance given me at all times to achieve my goals and aims and providing me with the postgraduate course that I receive.



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CONTENTS

ACKNOWLEDGEMENTS	i
ABSTRACT	ii
LIST OF FIGURES	iv
LIST OF TABLES	vi
ABBREVIATIONS	vii
1. INTRODUCTION	1
1.1 High Speed Network	1
1.2 Common Network	1
1.3 Optimum Network	2
1.4 Objectives	2
1.5 Methodology	2
1.5.1 Telephone and IP Traffic Forecast by Year 2015	3
1.5.2 Network Design	4
1.5.3 Network Simulation	4
2. LITERATURE REVIEW	5
2.1 Traffic Theory for Planning	5
2.1.1 Traffic Volume	5
2.1.2 Traffic Density	5
2.1.3 Calling Rate	6
2.1.4 Probability of Loss	6
2.1.5 Earlang's B Formula	7
2.2 Demand Forecasting	8
2.2.1 Telephone Demand Forecasting	9
2.2.1.1 Macro-level telephone Demand Forecasting	9
2.2.1.2 Extrapolation Method	10
2.2.1.3 Method of Comparison with other Countries	11
2.3 Traffic Forecasting	11
2.3.1 Introduction	11
2.3.2 The Gravity Model	11
2.4 Economic Indicators	12
2.4.1 Gross National Product	12
2.4.2 Gross Domestic Product	13
2.4.3 Factors of Production	13
2.5 WDM Technology	13
2.5.1 Optical Transmitters	14
2.5.2 Optical Receivers	15
2.5.3 Optical Multiplexers and Demultiplexers	15
2.5.4 Optical Add Drop Multiplexers	16
2.5.5 Amplifiers	16
2.6 Optical Amplifiers	17
2.6.1 Amplifier Wavelength Bands	17



2.6.2	Erbium Doped Fiber Amplifier	18
2.6.3	Raman Amplifier	19
2.6.4	Comparison of Raman and Erbium Doped Amplifiers	26
3.	TELEPHONE DEMAND FORECAST	29
3.1	Introduction	29
3.2	Income Elastic Model	29
4.	TELEPHONE TRAFFIC FORECAST	33
4.1	Nodes of the Network	33
4.2	Traffic Originated from each Node	35
4.3	Gravity Model	37
5.	INTERNET TRAFFIC FORECAST	38
5.1	Traffic Forecast of Internet Dial-up Users	38
5.2	Broadband Users	40
6.	VOICE OVER TRAFFIC FORECAST	43
6.1	Introduction	43
6.2	VoIP in Sri Lanka	43
6.3	Telephone Traffic migration from PSTN to VoIP	43
6.3.1	Traffic Migration of Business Customers from PSTN to VoIP	44
6.3.2	International Traffic Migration from PSTN to VoIP	44
6.3.3	Domestic Traffic Migration from PSTN to VoIP	45
6.3.4	Traffic Migration Patterns from PSTN to VoIP	45
7.	NETWORK DESIGN	48
7.1	Network Topology	48
7.2	Traffic Routing	50
7.3	Capacity of the Network	50
7.4	Wavelength allocation and connectivity	50
7.5	Selection of Wavelengths	53
7.6	Design Configuration	53
7.7	Selection of the Fiber	54
7.8	Selection of Sources and Detectors	55
7.9	Network Design using Optical Amplifiers	55
7.10	BER Objective and Design Steps	55
7.11	Network Design	55
7.11.1	Selecting a suitable Booster and Pre-Amplifier	55
7.11.2	Power Budget Calculations	56
7.11.3	OSNR Calculations of Segments	61
7.11.4	OSNR Calculations of Optical Line Sections	64
7.11.5	Estimating Q Factors and preparing of the Performance Budget	64
7.12	Dispersion Management	67



8. NETWORK SIMULATION	71
8.1 Introduction	71
8.2 Simulation Strategy	71
8.3 Optimum Results of the Network	71
8.4 Simulated Outputs of the Network	72
9. SUMMARY AND CONCLUSIONS	90
9.1 Telephone Demand and its distribution by year 2015	90
9.2 IP Traffic Demand and its distribution by year 2015	90
9.3 Network Topology and capacity requirements	91
9.4 Designing of a Repeaterless Optical Network	91
9.5 Modeling of the Network to ensure desired results	92
9.6 Suggestions for future work	92

REFERENCES

APPENDICES



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ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my Project Supervisor Prof. (Mrs.) I. J. Dayawansa (BSc Dip E.E. MSc PhD FIEE) for her guidance, valuable advices and encouragements for successfully completing this Postgraduate Research study.

Also I thank to University of Moratuwa for giving me an opportunity for a postgraduate study where I had the opportunity to explore in new technology areas like Repeaterless Optical Networks.

I should express my gratitude to ARTIS Software Corporation for providing me an evaluation copy of OptSim Software Tool for simulating and evaluating the designed Network.

Finally I thank to my lovely wife Mrs. J. N. Wickramasinghe and Sri Lanka Telecom for providing me necessary information and support for completing this project successfully.



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ABSTRACT

A reliable and wideband telecommunication network is a vital infrastructure development, where wide band services such as ATM, ADSL and IP based services could be supported. In Sri Lanka, the requirement of this kind of an optical network is very significant as other operators also can share the capacity of the network for transporting their traffic. On the other hand the network problems such as excessive BER (Bit Error Rate) etc are experienced after its construction. In order to avoid such limitations in the network, the network needs to be modeled on appropriate software tools and run with designed network parameters, so that the desired BER could be ensured.

During the initial phase of the study, the total telephone demand by year 2015 was estimated as nearly 2 million subscribers. This was estimated through the world trend for telephone subscribers together with economic indicators such as GNP and GDP.

The Nodes of the Network was determined based on the present distribution of customers in the County. In this case all the Tertiary Switching Center areas and the Secondary Center Areas where the customer base is more than 2.5% of total customers were taken as the main nodes of the network. In addition Jaffna and Batticaloa were also taken as nodes considering the potential growth of traffic in northern and eastern parts of the Island.

The Gravity model and Erlang's B formula, traffic tables, were used to find the traffic between nodes and the number of circuits between nodes. Based on the traffic distribution between nodes, a part of the network was proposed as a fully reliable Ring Network, while other nodes are connected through extended links. The IP traffic, which is thought to be the major traffic flow in the future, were estimated considering the broadband Internet growth in the country. Also the traffic, which are expected to be migrated from traditional PSTN to IP Network were identified and estimated to find the total bandwidth requirement of the network by year 2015.

The number of wavelengths in the proposed Network were decided based on the final bandwidth requirement. This resulted an island wide network consisting of WDM Ring Network having 08 wavelengths that basically covers the southern part of the country and two other extensions having a wavelength each to northern and eastern parts of the country. The Colombo and the Kandy nodes were selected as Full Fiber Terminal Stations as most of the traffic flow between these two nodes. Wavelengths are added and dropped at each branch station based on the traffic volumes between these nodes.

The wavelengths were selected such that the space between adjacent wavelengths is 0.8nm to avoid nonlinear effects and cross talks. The G.655 non-zero dispersion fiber was selected to manage the dispersion and non-linear effects. DFB and APD are the Source and the Detector respectively to suit long haul transmissions having narrow spectral widths and also to meet better sensitivity at the receiver.

The proposed Network is a Repeaterless Optical Network, where the Power Budget of the longest Segment, Kandy – Matara, of 280km was designed without employing a physical repeater, which needs power feeding. This was achieved using Raman Amplifiers as line repeaters and Erbium Doped Fiber Amplifiers (EDFA) as Boosters and Pre-Amplifiers. The Power Budget has been prepared for all other Segments as well based on appropriate configurations. Also the BER objective of 10^{-9} was ensured for the longest Optical Line Section of Colombo – Kandy via Matara, in which a couple of express wavelengths are assigned for carrying traffic between Colombo and Kandy. The Performance Budget was prepared for long Optical Line Sections and the calculated BER was found as better than 10^{-9} . This has been further confirmed by the Eye Diagrams after simulating the Network on the OptSim Network Simulator developed by ARTIS Software.



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LIST OF FIGURES

Figure 2.1 Offered Traffic and Carried Traffic	6
Figure 2.2 Factors affecting Demand	8
Figure 2.3 Economic Index Relating to Telephone Density	10
Figure 2.4 Traffic flow between Two Office	12
Figure 2.5 Typical WDM Multiplexer	15
Figure 2.6 WDM Demultiplexer using Wave Guide Grating Diffraction technique	16
Figure 2.7 Illustration of the advantage of using Optical Amplifiers	17
Figure 2.8 Typical Erbium Doped Fiber Amplifier	18
Figure 2.9 Energy Level Diagram of an Erbium Doped Fiber Amplifier	19
Figure 2.10 Energy Level Diagram of a Raman Amplifier	19
Figure 2.11 Gain Vs Frequency difference between the Signal and Pump	20
Figure 2.12 Configuration of the Forward Pumping Raman Amplifier	20
Figure 2.13 Configuration of the Backward Pumping Raman Amplifier	21
Figure 2.14 Hybrid Raman Doped Amplifier	28
Figure 3.1 World Telephone Demand Trend	30
Figure 5.1 Growth of Internet Users	39
Figure 5.2 Growth of Broadband users	41
Figure 5.3 Growth of Broadband users (log scale)	41
Figure 7.1 Topology of the Proposed Optical Fiber Network	49
Figure 7.2 Wavelength allocation and connectivity	52
Figure 7.3 Schematic Diagram of a WDM Segment	54
Figure 7.4 Simplest Configuration (Configuration-A) Fiber Link	57
Figure 7.5 Configuration-B of a Fiber Link	58
Figure 7.6 Configuration -C of a Fiber Link	58
Figure 7.7 Configuration-D of a Fiber Link	59
Figure 7.8 Measured EDF Gain and Noise Figure Vs. Pumping Power	59
Figure 7.9 Configuration of the proposed Network	70
Figure 8.1 Output of the Colombo main Fiber via Kurunegala	72
Figure 8.2 Input of the Kandy main Fiber via Kurunegala	73
Figure 8.3 Eye diagram of λ_1 at Kandy FFTS via Kurunegala	74
Figure 8.4 Eye diagram of λ_2 at Kandy FFTS via Kurunegala	74
Figure 8.5 Eye diagram of λ_3 at Kandy FFTS via Kurunegala	75
Figure 8.6 Eye diagram of λ_4 at Kandy FFTS via Kurunegala	75
Figure 8.7 Eye diagram of λ_5 at Kandy FFTS via Kurunegala	76
Figure 8.8 Eye diagram of λ_6 at Kandy FFTS via Kurunegala	76
Figure 8.9 Eye diagram of λ_7 at Kandy FFTS via Kurunegala	77
Figure 8.10 Eye diagram of λ_8 at Kandy FFTS via Kurunegala	77
Figure 8.11 Output of the Colombo main Fiber via Matara	78
Figure 8.12 Input of the Kandy main Fiber via Matara	79
Figure 8.13 Eye diagram of λ_1 at Kandy FFTS via Matara	80
Figure 8.14 Eye diagram of λ_2 at Kandy FFTS via Matara	80
Figure 8.15 Eye diagram of λ_3 at Kandy FFTS via Matara	81

Figure 8.16 Eye diagram of λ_4 at Kandy FFTS via Matara	81
Figure 8.17 Eye diagram of λ_5 at Kandy FFTS via Matara	82
Figure 8.18 Eye diagram of λ_6 at Kandy FFTS via Matara	82
Figure 8.19 Eye diagram of λ_7 at Kandy FFTS via Matara	83
Figure 8.20 Eye diagram of λ_8 at Kandy FFTS via Matara	83
Figure 8.21 Output of the Kurunegala Fiber	84
Figure 8.22 Input of the Anuradhapura Fiber	85
Figure 8.23 Eye Diagram at Anuradhapura Station	85
Figure 8.24 Output of the Anuradhapura Fiber	86
Figure 8.25 Input of the Jaffna Fiber	86
Figure 8.26 Eye Diagram at Jaffna Station	87
Figure 8.27 Output of the Kandy Fiber	88
Figure 8.28 Input of the Bataloa Fiber	88
Figure 8.29 Eye Diagram at Bataloa Station	89



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LIST OF TABLES

Table 2.1 Comparison of Raman and Erbium Doped Fiber Amplifiers	27
Table 3.1 Calculation of Total Telephone Demand at the end of each Year	31
Table 4.1 Distribution of Telephone Customers in year 2001	34
Table 4.2 Nodes of the network and its traffic distribution	36
Table 5.1 Growth of Internet users and its forecast	38
Table 5.2 Distribution of Internet users by year 2015 and Bandwidth requirement	39
Table 5.3 Growth of Broadband users	40
Table 5.4 Forecast of Broadband users	42
Table 5.5 Distribution of Broadband users by year 2015 and Bandwidth requirement	42
Table 6.1 Traffic migration patterns from traditional PSTN to VoIP	45
Table 6.2 International and a portion of Domestic traffic as VoIP	46
Table 7.1 Capacity Requirement of each Segment	50
Table 7.2 Wavelength Requirement of the Network	51
Table 7.3 Wavelengths in the Network	53
Table 7.4 Parameters of G655 Non-Zero Dispersion Shifted Fiber	54
Table 7.5 Typical Parameters of a Booster, Pre-Amplifier and Raman Amplifier	56
Table 7.6 Distances between Nodes of the Network	57
Table 7.7 Network Segments and its particular Configuration	60
Table 7.8 Power Budgets of Segments	61
Table 7.9 Parameters required for SNR Calculations	62
Table 7.10 SNR Calculations of Segments	63
Table 7.11 Performance Budget	67
Table 7.12 Dispersion Coefficients of each wavelength	68
Table 7.13 Lengths of DCF to compensate dispersion of each Segment and OLS	69

ABBREVIATIONS

ADP	-	Avalanche Photo Diode
ADSL	-	Asymmetric Digital Subscriber Line
ASE	-	Amplified Spontaneous Emission
BER	-	Bit Error Rate
BS	-	Branch Station
CR	-	Calling Rate
DCF	-	Dispersion Cut-off Fiber
DFB	-	Distribution Feed Back
DSF	-	Dispersion Shifted Fiber
DSL	-	Digital Subscriber Line
EDFA	-	Erbium Doped Fiber Amplifier
EOL	-	End of Life
ES	-	Extension Station
FFTS	-	Full Fiber Terminal Station
FWM	-	Four Wave Mixing
GDP	-	Gross Domestic Product
GNP	-	Gross National Product
IP	-	Internet Protocol
ITU	-	International Telecommunication Union
NF	-	Noise Figure
NI	-	Net Income
NZ-DSF	-	Non Zero Dispersion Shifted Fiber
OADM	-	Optical Add Drop Multiplexer
OLS	-	Optical Line Section
OSNR	-	Optical Signal to Noise Ratio
PC	-	Personal Computer
PCM	-	Pulse Code Modulation
PMD	-	Polarization Mode Dispersion
PSTN	-	Public Switched Telephone Network
RA	-	Raman Amplifier
SLT	-	Sri Lanka Telecom
SNR	-	Signal to Noise Ratio
SPM	-	Self Phase Modulation
SRS	-	Stimulated Raman Scattering
SSC	-	Secondary Switching Center
STM	-	Synchronous Transport Mode

TDM	-	Time Division Multiplexing
TRC	-	Telecommunication Regulatory Commission
USB	-	Universal Serial Bus
VOIP	-	Voice Over Internet Protocol
WDM	-	Wavelength Division Multiplexing



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